PLANETARY SCIENCE

Human Space Exploration Is About More Than Just Science

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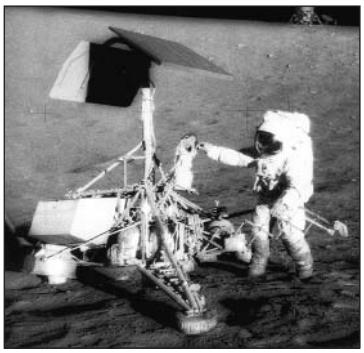
The recent loss of Columbia is forcing renewed debate over the future of human space flight. Any solution to solving the technical problems with the space shuttle must consider the objectives of human space flight in the next several decades. If not beyond Earth orbit, then the value of the enterprise will continually be questioned. And if we send our astronauts to explore deep space, how will that relate to the use of robots for deep-space exploration?

The continuing debate about robotic versus human exploration in the space program has proven more distracting than productive. These enterprises have coexisted and cooperated during the space program's long history and both have produced extraordinary achievements. The extensive robotic exploration of the Moon in the 1960s by both Americans and Soviets prepared the way for human exploration. The Cold War and the resulting race to land humans on the Moon assured the investments that allowed robotic scientific exploration to emerge from the cancellation of Apollo to become the extensive and robust enterprise that it is today.



Robotic and human space exploration. Astronaut Pete Conrad next to the robotic Surveyor III on the Moon.

The science community has long worried that the high cost of human space flight might overwhelm robotic space exploration. This has not occurred, because support for the two enterprises is not a zero-sum game. NASA's support for the Space Science program has grown substantially during the era of space station construction. And when human space exploration ultimately moves beyond Earth orbit, robotic exploration will have provided the necessary reconnaissance and support for human explorers.

The relevant question in the trade-off between implementing a goal by robots or humans is whether the investigation requires human explorers, with their associated cost. The argument often used to dismiss humans is that technology will produce a machine with sufficient intelligence and dexterity to render a human unnecessary. It may take too long or an unpredictable length of time to develop such a machine. No matter how clever or useful the robots we make, they will always be tools for enhancing human capabilities. The argument that our technology ultimately will produce a robot with the intelligence, experience base, and analytical capability of a human field investigator sounds incredible and should not be a deterrent to a restless human spirit yearning for exploration.

The lesson of more than 40 years of space exploration is that robots and humans have complementary roles. Humans are ideally suited to tasks requiring complex physical articulation, expert knowledge, judgment, and versatility, as demonstrated in the missions servicing the Hubble Space Telescope. Humans are ideally suited for intensive field study where real-time iterative observation, hypothesizing, testing, synthesizing, and reconstruction are necessary, as in the Apollo 17 geological explorations. Humans have clear advantages over robots for serendipitous discovery and response but are limited by safety considerations, the necessity for spacesuits, slow response time, and the cost of human life-support systems.

The advantage of robots is that they are inherently expendable and can be used where risks to humans are unacceptable. For example, it is entirely impractical for astronauts to explore the surface of Venus where the temperature is oppressively hot and the atmospheric pressure crushing. The disadvantage of robots is that they require human interaction and methods of remote control that are often cumbersome and delayed. Robots with human-like cognitive abilities will be a distant goal for a long time to come. In the meantime, robots should be used where there is no clear advantage to using humans, to provide relief from routine operational tasks, and to extend the sensory and manipulative capabilities of humans.

In any case, cost-effectiveness should not be used exclusively in assessing human versus robotic modes for scientific exploration, because the decision to proceed with human exploration will not be made on scientific grounds alone. Human exploration of space is motivated by societal factors other than science. Nonetheless, when a decision is made to continue human exploration beyond Earth orbit, it will provide a tremendous opportunity for scientist-explorers, and science should be a motivating force in defining human space exploration goals. The National Research Council report *The Human Exploration of Space* (*1*) states "Robotic options should be used until they provide enough information to…define a set of scientifically important tasks that can be performed by humans in situ. …It cannot be demanded that these tasks be best and most cost-effectively performed by humans."

Much of the antagonism in the science community toward human space flight is the result of NASA's marketing the space shuttle and international space station as science laboratories. Most science done by humans in Earth orbit, other than research on human physiology and psychology in space, can be done with automation and by remote control on unmanned orbital space-craft (*2*). If space explorers are to risk their lives, it should be for extraordinary reasons—such as exploration of the Moon, Mars, or asteroids, and for construction and servicing of large space telescopes. The whole point of leaving home is to go somewhere, not to endlessly circle the block. In truth, the shuttle and station are justifiable only as a means to maintain a human presence in space until society decides to undertake missions to destinations beyond Earth orbit. If this were admitted honestly, there might be more support in the science community for human space flight.

A space exploration enterprise that satisfies the public requires humans. In the minds of the public, robotic exploration is an extension of the human experience and a prelude to human exploration itself. Robotic exploration is the method of choice for reconnaissance and scientific investigation to the extent that robots can accomplish the desired goals. However, only human explorers will ultimately fulfill the public's sense of destiny in space.

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References and Notes

1. National Research Council, *The Human Exploration of Space* (National Academy of Sciences, Washington, DC, 1997), part 3, p. 12.
2. Compare M. Koss, Op-Ed, *New York Times*, 29 June 2003, p A13.